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(73) Proprietor: KABUSHIKI KAISHA ISHIDA KOKI SEISAKUSHO
44, Shogoin Sannou-cho Sakyo-ku
Kyoto-shi Kyoto 606 (JP)

(72) Inventor: Haze, Setsuo
2020-30, Miyagi Kagami Ryuoh-cho
Gamou-gun Shiga, 520-25 (JP)

(74) Representative: Fane, Christopher Robin King et al
HASELTINE LAKE & CO. Hazlitt House 28
Southampton Buildings Chancery Lane
London, WC2A 1AT (GB)

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Description

This inventi n relates t a m thod and apparatus for zero adjustment of a weighing machine for measuring the weight of articles.

A weighing machine employed in a combinatorial weighing system or the like includes a weight sensor and a weighing hopper (or weighing dish), the former comprising a load cell. Articles introduced into the weighing hopper are weighed by the weight sensor, the output whereof, which is indicative of the measured weight, is applied to a computerized combinatorial processing unit through an amplifier and an analog-to-digital converter (referred to as an AD converter). The combinatorial processing unit is operable to form combinations of weight values obtained from a plurality of the aforementioned weighing machines constituting the combinatorial weighing system, calculate the total weight of each combination, obtain a combination, referred to as an "optimum combination", whose total weight value is equal to a target weight value or closest to the target weight value within preset allowable limits, discharge the articles from the weighing hoppers of the weighing machines corresponding to the optimum combinations, whereby these weighing hoppers are left empty, resupply the emptied weighing hoppers of these weighing machines with articles in order to prepare for the next weighing cycle, and then repeat the foregoing steps in similar fashion to carry out a continuous automatic weighing operation.

The load cell and amplifier mentioned above have characteristics that vary with temperature. In addition, matter such as powder, oil and residua ascribable to the articles being weighed affix themselves to the weighing hopper with time. Therefore, unless certain measures are taken, the tare weight signal output from the associated weighing machine tends to vary, thereby making it impossible to maintain good weighing precision. Accordingly, in the prior art, a zero-point adjustment circuit is provided for each and every weighing machine, and a zero-point adjustment is effected by the circuit to deal with a fluctuation in the tare weight value caused by a change in temperature and by the accumulation of residua or the like. However, since this conventional zero-point adjustment is performed by manual control of a variable resistor in the zero-point adjustment circuit, adjustment requires considerable time and effort, particularly when there are a large number of weighing machines.

WO—A—80/01851 relates to method and apparatus for compensating for drift of the null point of a measuring device.

WO—A—80/01851 acknowledges US—A—4 043 412 at background art. US—A—4 043 412 relates to drift compensation in connecti n with a counting scale for providing a display of the weight of articles placed on the scale.

WO—A—80 01851 is concern d particularly with c mpensation for drift of the null point f a measuring device suitable for use with a signatur v rification device.

WO—A—80 01851 uses complicated iterative processes, which may be provided with positive and negative (P and N) iteration loops and with facilities for averaging. However, basic operation can be understood by considering the positive iteration loop. In each iteration of the P (positive) loop, a compensating signal is compared with a null point measurement output signal. The result of this comparison (the difference between the compared values) is a comparison output signal. The comparison output signal is compared with the stored value of the comparison output signal in the previous iteration. If the comparison output signal is greater than the stored value a fault is considered to exist. If the comparison output signal is less than the stored value, the stored value is replaced by the present value of the comparison output signal (with a tolerance value). If the comparison output signal is of zero value, operations are terminated. If the value is not zero, the compensating signal is increased in value by one step and a further loop iteration initiated. All step increases are single unit incremental changes.

For the first pass through the P loop the compensating signal has a zero value and a suitable initial value set as a stored value for the comparison output signal.

EP—A—0 060 701 relates to the zero adjustment of weight sensors and is concerned with weight sensors in a combinatorial weighing system.

According to the present invention there is provided a method of automatically adjusting the zero point of a weighing machine, comprising the steps of:

(a) providing a zero-point correction value of a preselected initial magnitude;

(b) calculating a difference value between the zero-point correction value and an unloaded weight value produced by the weighing machine when the machine is free of load;

(c) comparing the difference value with a preset reference value of a predetermined magnitude;

(d) changing the zero-point correction value in accordance with the relative magnitudes of the compared values; and thereafter;

repeating steps (b) to (d), to render the difference value substantially equal to the preset reference value.

According to the present invention there is also provided zero-point adjustment apparatus for use with a weighing machine operable to provide an output giving a weight value which depends upon the load weight applied to the weighing machine, the apparatus comprising:

a subtractor operable to calculate a difference valu between a z ro-p int correcti n value, initially of a preselected magnitude, provided by the apparatus and an unl aded weight value produced by the weighing machine when the machine is fr of load;

a comparat r p rabl t c mpare the differ-

ence valu with a preset reference value (Wr) of a predetermined magnitude and to provide an output the value of which is dependent up n the relative magnitudes of the values compared;

a control unit p rable to change the zero-point correction value in accordance with the value of the output of the comparator, which changed zero-point correction value is supplied to the subtractor for further operation of the subtractor, the comparator and the control unit, to render the difference value substantially equal to the preset reference value.

An embodiment of the present invention can provide a zero-point adjustment method and apparatus through which a weighing machine can be subjected to a zero-point adjustment automatically.

Another embodiment of the present invention can provide a zero-point adjustment method and apparatus through which a weighing machine can be subjected to a zero-point adjustment in a short period of time.

A further embodiment of the present invention can provide a zero-point adjustment method and apparatus through which a highly precise weighing operation can be performed.

According to an embodiment of the present invention, a subtractor calculates the difference value between an "unloaded" weight value produced by a weighing machine in the unloaded state, and a zero-point correction value produced by a control unit. The zero-point correction value is changed in such a manner that the calculated difference value is made to approach a preset value, and the resulting zero-point correction value is subtracted from a weight value produced by the weighing machine when it is loaded with articles applied thereto, thereby measuring the weight of the articles. The control unit produces, in the form of a digital value, an initial zero-point correction value when the weighing machine is in the unloaded state, the subtractor calculates the difference value between the unloaded weight value, which is produced by the empty weighing machine, and an analog value obtained from a digital-to-analog converter for converting the digital value into said analog value, the difference value and the preset value are compared, and the zero-point correction value is sequentially changed in accordance with the results of the comparison operation to render the difference value equal, or nearly equal, to the preset value.

Reference will now be made, by way of example, to the accompanying drawings, in which like reference charcters designate the same or similar parts throughout the figures thereof, and in which:—

Fig. 1 is a block diagram illustrating apparatus embodying the present invention;

Fig. 2 is a graph showing the corresponding relation between the digital value of an output signal, which is produced by an AD converter in the apparatus of Fig. 1, and weight in grams;

Fig. 3 is a graph showing the c rresp nding relation between the digital value f an input signal, which is applied to a zero-adjustment DA conv rter in the apparatus of Fig. 1, and th utput v ltag f th DA converter;

Fig. 4 is a flowchart illustrating processing for a zero-point adjustm nt method embodying the present invention; and

Fig. 5 is a flowchart illustrating processing for weight measurement.

Reference will first be made to Fig. 1, which illustrates zero-point adjustment apparatus embodying the present invention. Numerals 101-1... 101-n denote n-number of weighing machines each of which comprises a weight sensor and a weighing hopper, not shown. Numerals 102-1...102-n denote n-number of amplifiers each of which has its input side connected to output terminals of a corresponding one of the weighing machines, each amplifier having a differential amplifier DAMP, a resistor R and a variable resistor VR. The amplifiers 102-1...102-n produce respective output signals having values W1...Wn indicative of the amplified weight signals obtained from the weighing machines. A multiplexer 103, comprising an analog switch or the like, receives the weight values Wi(i=1, 2...n) from the amplifiers and delivers these as output signals in successive fashion in response to a weight value read signal WRS, described below. A subtractor 104 calculates the difference Ws between each weight value Wi received from the multiplexer 103, and a zero-point correction value Wc produced by a voltage divider 109. A sequential comparison-type AD converter 105 converts the difference Ws, which is an analog voltage value into a 12-bit digital value Wd. It should be noted that the difference Ws has a value ranging between 0v and approximately 11v, and that the digital value Wd ranges between 0 and 4095. The arrangement is such that one digit of the digital value Wd from the AD converter 105 is equivalent to 0.1 g, with a digital value of 0 corresponding to −5g, a digital value of 50 to 0 g, and a digital value of 4095 to 404.5 g, as shown in Fig. 2. A comparator 106 compares the magnitude of a preset value Wr with that of the difference Ws produced by the subtractor 104, and generates a signal CRS the value of which is logical "1" when Ws>Wr is found to hold. The value Wr is preset to, e.g., 0.12 v, which is equivalent to an output value of approximately 50 from the AD converter 105.

Numeral 107 denotes a control unit comprising a processor 107a for executing processing in accordance with a processing program, a ROM (read-only memory) 107b for storing the processing program, which is for executing span adjustment, automatic zero-point adjustment and combinatorial processing, and a RAM (random-access memory) 107 c for the writing and reading of data. The control unit 107 produces a zero-point correction value Wz, which is 10-bit digital valu , and applies the value of a DA conv rter 108, wh re th value Wz is convert d int a v ltag , namely an anal g zero-p int corr ction value Wz'. The relation betwe n Wz and Wz' is as sh wn in Fig. 3. Specifically, the DA converter 108

subjects th digital value Wz t a DA conversion in such a manner that digital values of 1023 and 0 are made equivalent to 10 v and 0 v, respectively, and in such a manner that the utput voltage Wz' is made proportional to the input Wz. The output voltage Wz' is applied to the aforementioned voltage divider 109, which is for effecting a level adjustment by dividing the output voltage Wz' of the DA converter 108 by 11 to produce the aforementioned zero-point correction value Wc.

Numeral 110 denotes a control panel including a switch 110a for requesting execution of a zero-point or span adjustment, a weight setting unit 110b for setting a target weight value Wa, a upper limiting setting unit 110c, a lower limit setting unit 110d, and a display unit 110e. The upper and lower limit setting units 110c, 110d are for setting upper and lower (maximum and minimum) limit values Ma, Mi, respectively, of an allowable range desired for the total weight of a combination. Numeral 111 designates a discharge control unit.

Reference will now be made to the flowchart of Fig. 4 to describe an automatic zero-point correction performed by the apparatus of Fig. 1. We will assume that the variable resistors VR of the amplifiers 102-1 through 102-n corresponding to the weighing machines 101-1 through 101-n are to be adjusted at the time that the combinatorial weighing system is installed on-site, and that the adjustment is to be performed, while viewing the display on the display unit 110e of the control panel 110, in such a manner that the zero-point adjustment value Wz (a 10-bit digital value) for each weighing machine takes on a value of 512 (i.e., in such a manner that an output of 0.45 v is produced by the voltage divider 109) when the weighing machines are free of an applied load. This is to effect a conversion into a digital value and make possible a zero-point adjustment with respect to a digital value of 511 evean if the zero point should deviate in the positive or minus direction.

(1) To perform a zero-point adjustment, the operator leaves the weighing machines unloaded and presses the switch 110a on the control panel 110 to request an automatic zero-point adjustment of the control unit 107.

(2) When the switch 110a is pressed, the processor 107a delivers the weight value read signal WRS to the multiplexer 103. The latter responds by successively delivering unloaded weight signals W1, W2...Wn received from the respective weighing machines 101-1...101-n via the amplifiers 102-i (i=1, 2...n). The following description will relate to a particular weight value Wi produced as an output by the multiplexer 103.

(3) Under the control of the zero-point adjustment processing program stored in the ROM 107b, the processor 107a delivers the value 512 in the form of a 10-bit binary numeral value f which nly the tenth bit is "1", th first through ninth bits being "0". The valu 512 serves as a z ro-p int correcti n value Wzi (that is, a zer -point correction value Wz with respect to the weight value Wi). This value is stored in the RAM 107c at a storage area MEMi corresponding to the weighing machin 101-i which has produced the weight value Wi as its output. This intiial zero-point correction value (first digital value) 512 (=1000000000) is coverted into a voltage, or analog signal, by the DA converter 108, and the voltage is divided by the voltage divider 109 to produce the signal Wc, which is applied to one input terminal of the subtractor 104.

(4) Applied to the other input terminal of the subtractor 104 is the weight value Wi from the weighing machine 101-i, which is in the unloaded state. The subtractor 104 therefore performs the following operation to calculate the difference Ws and produce an output signal indicative thereof:

$$Wi=Wc \rightarrow Ws \qquad (1)$$

(5) The difference Ws is applied to the comparator 106, and is converted by the AD converter 105 into a digital value Wdi, which is read in by the processor 107a and stored thereby in the storage area MEMi of the RAM 107c.

(6) The comparator 106, which compares the difference Ws and the preset value Wr in magnitude, produces a logical "1" output when Ws>Wr holds, and a logical "0" output when Ws≤Wr holds.

(7) The processor 107a discriminates the output of the comparator 106, namely the logic level of the output signal CRS produced thereby. If CRS is logical "1" (i.e., Ws>Wr), the ninth bit of the first digital Wzi is changed to logical "1" (i.e., 1000000000→1100000000); if CRS is logical "0" (i.e., Ws≤Wr), then the tenth bit of the first digital value is changed to logical "0" and the ninth bit is changed to logical "1" (i.e., 1000000000→0100000000). In either case, the resulting digital value, namely a second digital value 768 (=1100000000) or 256 (=0100000000) is produced by the processor 107a as the zero-point correction value Wzi. The processor 107a also uses this second digital value to update the zero-point correction value stored in the storage area MEMi of the RAM 107c. The updated zero-point correction value Wzi is applied to the subtractor 104 through the DA converter 108 and voltage divider 109.

(8) Thereafter, via the foregoing steps (4) through (6), the difference Ws is calculated, Ws is converted into a digital value, the digital value Wdi stored in the storage area MEMi of the RAM 107c is updated, and the maghitude of the difference Ws is compared with the magnitude of the preset value Wr.

(9) If the signal CRS produced by the comparator 106 is logical "1" (Ws>Wr), the processor 107a changes the eighth bit of the second digital value to "1". If CRS is logical "0" (Ws≤Wr), the ninth bit f the second digital value is changed to "0" and the eighth bit to "1". In either case, the result is a third digital valu delivered as a new z ro-p int c rrection value Wzi. Th processor 107a uses this third digital valu f update the zero-p int correction value

Wzi stored in the storage area MEMi of the RAM 107c.

Th ncef rth, by performing the foreg ing steps in the manner described ab ve, the apparatus repeats the pr cessing f r calculating the difference Ws, converting the difference into a digital value and comparing the difference Ws and the preset value, as well as the processing for altering the zero-point correction value Wzi based on the result of the comparison step (which is processing similar to the AD conversion processing performed by a sequential-type AD converter). The foregoing process steps are repeated until the first bit of the zero-point correction value is specified, whereby the zero-point correction value Wzi is finally determined. At the instant the zero-point correction value Wzi is delivered by the processor 107a, the difference Ws produced by the subtractor 104 is equal, or nearly equal, to the preset value Wr. It should be noted that the finally determined zero-point correction value Wzi, and the output Wdi of the AD converter 105 that prevails when this zero-point correction value Wzi is produced, are stored in the storage area MEMi of the RAM 107c.

Thereafter, through the foregoing process steps, the zero-point correction values Wz and AD converter outputs Wd for all of the weighing machines 101-1 through 101-n are obtained and stored in the RAM 107c. When this has been accomplished, zero-point adjustment processing ends.

Upon the completion of zero-point adjustment processing, articles are introduced into the weighing machines 101-1 through 101-n and a start signal (timing signal) SRS is produced by a packaging machine, which is not shown. The control unit 107 responds to the signal SRS by executing processing in accordance with the flowchart of Fig. 5 to measure the weight of the articles in each weighing machine. The process steps are as follows:

(a) When the start signal STS is generated, the processor 107a produces the weight value read signal WRS and applies the signal WRS to the multiplexer 103.

(b) The multiplexer 103 responds to the arrival of the weight value read signal WRS by delivering the weight value W1 produced by the weighing machine 101-1, and by supplying the DA converter 108 with the zero-point correction value Wz1 for the weighing machine 101-1, which value is obtained from the storage area MEM1 of the RAM 107c.

(c) Using W1 and the analog zero-point correction value Wc1 produced by the voltage divider 109, the subtractor 104 generates the difference Ws by performing the following operation:

$$W1-Wc1 \rightarrow Ws \qquad (2)$$

The AD converter 105 subjects the difference Ws to an AD c nversion and applies the resulting digital value Wd to the processor 107a.

(d) Using the digital value Wd and the digital Wd1, which has been stored in the storage area MEM1 of the RAM 107c owing to the above-described zero-point adjustm nt processing, the pr cessor 107a performs the following operations:

$$Wd-Wd1 \rightarrow W'1 \qquad (3)$$

to calculate the weight W'1 of the articles introduced into the weighing machine 101-1. The processor then stores W'1 in the RAM 107c.

(e) When calculation of the weight W'1 of the articles contained in the weighing machine 101-1 is completed, the multiplexer 103 delivers the weight value W2 received from the weighing machine 101-2 via the amplifier 102-2, and the processor 107a supplies the DA converter 108 with the zero-point correction value Wz2 for the weighing machine 101-2, Wz2 being obtained from the storage area MEM2 of the RAM 107c. The processor 107a then repeats steps (c), (d) to calculate the weight W'2 of the articles contained in the weighing machine 102-2 and to store W'2 in the RAM 107c.

Thereafter, the control unit 107 calculates the weight values Wi (i=1, 2...n) of the articles contained in all of the weighing machines, executes well-known combinatorial processing following completion of the foregoing calculations, calculates the total weight of each of the combinations obtained, finds an optimum combination, namely a combination whose total weight value is equal to the target weight value Wa or closest to the target weight value Wa within preset allowable limits (i.e., between Mi and Ma), sends a discharge signal to the discharge control unit 111 to discharge the articles from the weighing machines corresponding to the optimum combination, and executes the next combinatorial weighing cycle after resupplying the weighing machines that have discharged their articles.

In the illustrated embodiment, all weighing machines are subjected to a zero-point adjustment in sequential fashion before a weighing operation. It should be noted, however, that a zero-point adjustment can be effected for a prescribed weighing machine while a combinatorial weighing operation is in progress. Specifically, according to this approach, after the weighing machines belonging to the optimum combination discharge their articles, a single weighing machine, by way of example, is selected from those which have discharged, this weighing machine is prohibited from being resupplied and then, during the next combinatorial weighing cycle, is subjected to a zero-point adjustment, this being the only weighing machine thus treated. This selected weighing machine is resupplied at the end of this next cycle, namely when the optimum combinati n f w ighing machines s lected by this cycle is resupplied.

In the cas described ab ve, the present invention is applied to zero-point adjustm nt of the weighing machin s c nstituting a combinatorial

weighing system. However, it goes without saying that the invention is not limited to such applicati n but can b m dified in various ways within the scope of the claims.

Claims

1. A method of automatically adjusting the zero point of a weighing machine, comprising the steps of:

(a) providing a zero-point correction value (Wz, Wz', Wc, Wzi) of a preselected initial magnitude;

(b) calculating a difference value (Ws, Wd, Wdi) between the zero-point correction value (Wz, Wz', Wc, Wzi) and an unloaded weight value (Wi) produced by the weighing machine when the machine is free of load;

(c) comparing the difference value (Ws, Wd, Wdi) with a preset reference value (Wr) of a predetermined magnitude;

(d) changing the zero-point correction value (Wz, Wz', Wc, Wzi) in accordance with the relative magnitudes of the compared values; and thereafter

repeating steps (b) to (d), to render the difference value (Ws, Wd, Wdi) substantially equal to the preset reference value (Wr).

2. A method as claimed in claim 1, the preselected magnitude of the zero-point correction value (Wz, Wz', Wc, Wzi) being mid way between minimum and maximum possible magnitudes of the zero-point correction value, wherein, in the first performance of steps (b) to (d), if a first condition arises, in which the difference value (Ws, Wd, Wdi) is greater in magnitude than the preset reference value (Wr), the zero-point correction value is increased in magnitude, and if a second condition arises, in which the difference value (Ws, Wd, Wdi) is less than or equal in magnitude to the preset reference value (Wr) the zero-point correction value is decreased in magnitude, the size of the increase or decrease being half the said preselected magnitude, and wherein, in each subsequent performance of steps (b) to (d), the zero-point correction value is subject to an increase or a decrease in magnitude, depending on which of the first or second conditions arises, of half the size of the increase or decrease in the preceding performance of steps (b) to (d).

3. A method as claimed in claim 2, wherein the zero-point correction value (Wz, Wz', Wc, Wzi) is provided as a digital value (Wz, Wz', Wzi) in the form of an m-bit binary number, the zero-point correction value being provided with the preselected initial magnitude of step (a) by setting the mth bit of the binary number of "1" and the remaining bits to "0",

and wherein, in the first performance of steps (b) to (d), if the first condition arises, the (m-1)th bit of the binary number is set to "1" with the mth bit unchanged, wher as if the second condition arises the mth bit is set to "0" and th (m-1)th bit set t "1", then in th nth performance of st ps (b) to (d), where n is an int ger greater than 1, if th first condition arises the (m-n)th bit of th binary number is set to "1" with the mth to (m−n+1)th bits unchanged, and if the second condition arises the (m−n+1)th bit is set to "0" and the (m−n)th bit set to "1".

4. A method as claimed in claim 3, wherein the calculation of step (b) is effected on the basis of an analog weight value (Wi) and an analog version (Wc) of the zero-point correction value obtained by digital-to-analog conversion of the m-bit binary number, and the comparison of step (c) is effected on the basis of the analog result (Ws) of that calculation and an analog preset reference value (Wr).

5. Zero-point adjustment apparatus for use with a weighing machine operable to provide an output giving a weight value which depends upon the load weight applied to the weighing machine, the apparatus comprising:

a subtractor (104) operable to calculate a difference value (Ws, Wd, Wdi) between a zero-point correction value (Wz, Wz', Wc, Wzi), initially of a preselected magnitude, provided by the apparatus and an unloaded weight value (Wi) produced by the weighing machine (101-1 to 101-n, 102-1 to 102-n) when the machine is free of load;

a comparator (106) operable to compare the difference value (Ws, Wd, Wdi) with a preset reference value (Wr) of a predetermined magnitude and to provide an output (CRS) the value of which is dependent upon the relative magnitudes of the values compared;

a control unit (107) operable to change the zero-point correction value (Wz, Wz', Wc, Wzi) in accordance with the value of the output (CRS) of the comparator, which changed zero-point correction value is supplied to the subtractor (104) for further operation of the subtractor (104), the comparator (106) and the control unit (107), to render the difference value (Ws, Wd, Wdi) substantially equal to the preset reference value (Wr).

6. Apparatus as claimed in claim 5, the initial preselected magnitude of the zero-point correction value (Wz, Wz', Wc, Wzi) being set mid way between minimum and maximum possible magnitudes of the zero-point correction value, wherein, in a first operation of the subtractor (104), comparator (106) and control unit (107), with the zero-point correction value set to the initial preselected magnitude, if a first condition arises, in which the difference value (Ws, Wd, Wdi) is greater in magnitude than the preset reference value (Wr), the zero-point correction value is increased in magnitude, and if a second condition arises, in which the difference value (Ws, Wd, Wdi) is less than or equal in magnitude to the preset reference value (Wr) the zero-point correction value is decreased in magnitude, the size of the increase or decrease being half the said preselected magnitude, and wherein, in each subsequent operation of the subtractor (104), comparator (106) and control unit (107) the z ro-p int correcti n value is subj ct t an incr as or a decrease in magnitude, d p nding on which of the first or second c nditi ns arises, of half the

siz f the increase or decrease in th pr ceding peration.

7. Apparatus as claimed in claim 6, wherein the zero-point correction value (Wz, Wz', Wc, Wzi) is provided as a digital value (Wz, Wz', Wzi) in the form of an m-bit binary number, the zero-point correction value being provided with the preselected initial magnitude by setting the mth bit of the binary number to "1" and the remaining bits to "0",

and wherein, in the first operation of the subtractor (104), comparator (106) and control unit (107), if the first condition arises, the (m−1)th bit of the binary number is set to "1" with the mth bit unchanged, whereas if the second condition arises the mth bit is set to "0" and the (m−1)th bit set to "1", then in the nth operation of the substractor (104), comparator (106) and control unit (107), where n is an integer greater than 1, if the first condition arises the (m−n)th bit of the binary number is set to "1" with the mth of (m−n+1)th bits unchanged, and if the second condition arises the (m−n+1)th bit is set to "0" and the (m−n)th bit set to "1".

8. Apparatus as claimed in claim 5, 6 or 7, wherein the subtractor (104) is arranged to receive an analog weight value (Wi) and an analog version (Wc) of the zero-point correction value obtained by digital-to-analog conversion of the m-bit binary number, and the comparator (106) is arranged to receive the analog result (Ws) of the calculation of the subtractor (104) and an analog preset reference value (Wr).

9. Apparatus as claimed in claim 8, comprising a digital-to-analog converter (108) and a voltage divider (109) operable to derive the analog version (Wc) of the zero-point correction value from the m-bit binary number.

10. Apparatus as claims in claim 5, 6, 7, 8 or 9, wherein the control unit (107) is operable to store a digital representation (Wz, Wzi) of the zero-point correction value ultimately achieved when the difference value (Wz, Wd, Wdi) has been rendered substantially equal to the present reference value (Wr), and to store a digital representation (Wd, Wdi) of that difference value, whereby when a weight value is read from the weighing machine, a true weight value is obtained by subtracting the stored difference value from the difference between the read weight value and the zero point correction value.

11. Apparatus as claimed in claim 5, 6, 7, 8, 9 or 10, for use with a combinatorial weighing system comprising a plurality of such weighing machines (101-1 to 101-n, 102-1 to 102-n), operable to perform zero-point adjustment for all of the weighing machines.

Patentansprüche

1. Verfahren zum automatischen Justieren des Nullpunktes einer Wägemaschin mit den folgenden Schritten:

(a) Lief rn eines Nullpunkt-Korrekturwertes (Wz, Wz', Wc, Wzi) mit vorgewählter Anfangsgröße;

(b) Berechnen eines Differenzwertes (Ws, Wd, Wdi) zwischen d m Nullpunkt-Korr kturwert (Wz, Wz', Wc, Wzi) und einem Leergewichtswert (Wi), d r von der Wäg maschin rzeugt wird, wenn die Maschine unbelastet ist;

(c) Vergleichen des Differenzwertes (Ws, Wd, Wdi) mit einem voreingestellten Referenzwert (Wr) von vorbestimmter Größe;

(d) Verändern des Nullpunkt-Korrekturwertes (Wz, Wz', Wc, Wzi) entsprechend den relativen Größen der verglichenen Werte; und danach

Wiederholen der Schritte (b) bis (d) um den Differenzwert (Ws, Wd, Wdi) im wesentlichen gleich dem voreingestellten Referenzwert (Wr) zu machen.

2. Verfahren nach Anspruch 1, wobei die vorgewählte Größe des Nullpunkt-Korrekturwertes (Wz, Wz', Wc, Wzi) in der Mitte zwischen dem möglichen Minimum- und Maximumgrößen des Nullpunkt-Korrekturwertes liegt, bei dem, bei der ersten Ausführung der Schritte (b) bis (d), wenn ein erster Zustand eintritt, in welchem die Größe des Differenzwertes (Ws, Wd, Wdi) größer ist als der voreingestellte Referenzwert (Wr), die Größe des Nullpunkt-Korrekturwertes gesteigert wird, unf wenn ein zweiter Zustand eintritt, bei welchem die Größe des Differenzwertes (Ws, Wd, Wdi) kleiner oder gleich dem voreingestellten Referenzwert (Wr) ist, der Nullpunkt-Korrekturwert in seiner Größe verringert wird, wobei das Ausmaß der Steigerung oder der Verringerung die Hälfte der vorgewählten Größe beträgt, und bei dem bei jeder folgenden Ausführung der Schritte (b) bis (d) der Nullpunkt-Korrekturwert, in Abbängigkeit davon ob der erste oder der zweite Zustand eintritt, in seiner Größe um die Hälfte der Steigerung oder Verringerung bei der vorangegangenen Ausführung der Schritte (b) bis (d) vergrößert oder verringert wird.

3. Verfahren nach Anspruch 2, bei dem der Nullpunkt-Korrekturwert (Wz, Wz', Wc, Wzi) als Digitalwert (Wz, Wz', Wzi) in Form einer m-Bit Binärzahl vorliegt, wobei der Nullpunkt-Korrekturwert mit seiner vorgewählten Anfangsgröße von Schritt (a) versehen wird, indem das m-te Bit der Binärzahl auf "1" und alle übrigen Bits auf "0" gestellt werden,

und bei dem bei der ersten Ausführung der Schritte (b) bis (d), wenn der erste Zustand eintritt, das (m−1)-te Bit der Binärzahl bei unverändertem m-ten Bit auf "1" gestellt wird, während, wenn der zweite Zustand eintritt, das m-te Bit auf "0" und das (m−1)-te Bit auf "1" gestellt wird und sodann bei der n-ten Ausführung der Schritte (b) bis (d), wobei n eine ganze Zahl größer als 1 ist, wenn der erste Zustand eintritt, das (m−n)-te Bit der Binärzahl bei unveränderten m-ten bis (m−n+1)-ten Bits auf "1" gestellt wird, und wenn der zweite Zustand eintritt, das (m−n+1)-te Bit auf "0" und das (m−n)-te Bit auf "1" gestellt wird.

4. Verfahren nach Anspruch 3, bei dem di Berechnung v n Schritt (b) auf der Grundlage eines analogen Gewichtswertes (Wi) und einer durch eine Digital-Analog-Wandlung der m-Bit Binärzahl erhaltenen analog n V rsi n (Wc) des

Nullpunkt-Korrekturwertes und der Vergleich von Schritt (c) auf der Basis des anal gen Ergebnisses (Ws) dieser Berechnung und eines analog n voreingestellt n R ferenzwertes (Wr) erfolgt.

5. Nullpunktjustierungsvorrichtung zur Anwendung bei einer Wägemaschine, zum Liefern eines Ausgangssignals, welches einen Gewichtswert angibtt, der von der Last abhängig ist, welche der Wägemaschine zugeführt wird, mit:

einem Substrahierer (104) zum Berechnen eines Differenzwertes (Ws, Wd, Wdi) zwischen einem von der Vorrichtung gelieferten Nullpunkt-Korrekturwert (Wz, Wz', Wc, Wzi), anfänglich mit einer vorgewählten Größe, und einem Leergewichtswert (Wi), der von der Wägemaschine (101-1 bis 101-n, 102-1 bis 102-n) erzeugt wird, wenn die Maschine unbelastet ist;

einem Komparator (106) zum Vergleichen des Differenzwertes (Ws, Wd, Wdi) mit einem voreingestellten Referenzwert (Wr) von vorbestimmter Größe und zum Liefern eines Ausgangssignals (CRS), dessen Wert von den relativen Größen der verglichenen Werte abhängt;

einer Steuereinheit (107) zum Verändern des Nullpunkt-Korrekturwertes (Wz, Wz', Wc, Wzi) entsprechend dem Wert des Ausgangssignals (CRS) des Komparators, wobei der veränderte Nullpunkt-Korrekturwert dem Subtrahierer (104) zum weiteren Betrieb des Subtrahierers (104), des Komparators (106) und der Steuereinheit (107) zugeführt wird, um des Differenzwert (Ws, Wd, Wdi) dem voreingestellten Referenzwert (Wr) im wesentlichen gleich zu machen.

6. Vorrichtung nach Anspruch 5, wobei die vorgewählte Anfangsgröße des Nullpunkt-Korrekturwertes (Wz, Wz', Wc, Wzi) auf die Mitte zwischen den möglichen Minimal- und Maximalgrößen des Nullpunkt-Korrekturwertes eingestellt ist, bei der bei einem ersten Betrieb des Subtrahierers (104), des Komparators (106) und der Steuereinheit (107), wobei der Nullpunkt-Korrekturwert auf die vorgewählte Anfangsgröße eingestellt ist, wenn ein erster Zustand eintritt, bei welchem die Größe des Differenzwert (Ws, Wd, Wdi) größer ist als der voreingestellte Referenzwert (Wr), der Nullpunkt-Korrekturwertes in seiner Größe gesteigert wird, und wenn ein zweiter Zustand eintritt, bei welchem der Differenzwert (Ws, Wd, Wdi) kleiner oder gleich dem voreingestellten Referenzwert (Wr) ist, der Nullpunkt-Korrekturwert in seiner Größe verringert wird, wobei das Ausmaß der Steigerung oder der Verringerung die Hälfte der vorgewählten Größe beträgt, und bei dem bei jedem folgenden betrieb des Subtrahierers (104), des Komparators (106) und der Steuereinheit (107) der Nullpunkt-Korrekturwert, in Abhängigkeit davon ob der erste oder der zweite Zustand eintritt, in seiner Größe um die Hälfte der Steigerung oder Verringerung bei dem vorangegangenen Betrieb vergrößert oder verringert wird.

7. Vorrichtung nach Anspruch 6, b i der d r Nullpunkt-Korrekturwert (Wz, Wz', Wc, Wzi) als Digitalw rt (Wz, Wz', Wzi) in Form einer m-Bit Binärzahl geliefert wird, wobei der Nullpunkt-K rrekturwert mit seiner vorgewählten Anfangsgröße versehen wird, indem das m-t Bit der hinärzahl auf "1" und alle übrigen Bits auf "0" gestellt w rden,

und bei dem beim ersten Betrieb des Subtrahierers (104), des Komparators (106) und der Steuereinheit (107), wenn der erste Zustand eintritt, das (m−1)-te Bit der Binärzahl bei unverändertem m-ten Bit auf "1" gestellt wird, während, wenn der zweite Zustand eintritt, das m-te Bit auf "0" und das (m−1)-te Bit auf "1" gestellt wird und sodann beim n-ten Betrieb des Subtrahierers (104), des Komparators (106) und der Steuereinheit (107), wobei n eine ganze Zahl größer als 1 ist, wenn der erste Zustand eintritt, das (m−n)-te Bit der Binärzahl bei unveränderten m-ten bis (m−n+1)-ten Bits auf "1" gestellt wird, un wenn der zweite Zustand eintritt, das (m−n+1)-te Bit auf "0" und das (m−n)-te Bit auf "1" gestellt wird.

8. Vorrichtung nach Anspruch 5, 6 oder 7, bei der der Subtrahierer (104) zum Empfang eines analogen Gewichtswertes (Wi) und einer durch Digital-Analog-Wandlung der m-Bit Binärzahl erhaltenen analogen Version (Wc) des Nullpunkt-Korrekturwertes ausgebildet, und der Komparator (106) zum Empfang des analogen Ergebnisses (Ws) der Berechnung des Subtrahierers (104) und eines analogen voreingestellten Referenzwertes (Wr) ausgebildet ist.

9. Vorrichtung nach Anspruch 8 mit einem Digital-Analog-Wandler (108) und einem Spannungsteiler (109) zum Ableiten der analogen Version (Wc) des Nullpunkt-Korrekturwertes aus der m-Bit Binärzahl.

10. Vorrichtung nach Anspruch 5, 6, 7, 8 oder 9, bei der die Steuereinheit (107) zum Speichern einer digitalen Darstellung (Wz, Wzi) des Nullpunkt-Korrekturwertes, der schließlich erreicht wird, wenn der Differenzwert (Ws, Wd, Wdi) dem voreingestellten Referenzwert (Wr) im wesentlichen gleich gemacht wurde, und zum Speichern einer digitalen Darstellung (Wd, Wdi) dieses Differenzwertes betreibbar ist, wodurch, wenn ein Gewichtswert aus der Wägemaschine gelesen wird, ein wahrer Gewichtswert durch Subtrahierten des gespeicherten Differenzwertes von der Differenz zwischen dem gelesenen Gewichtswert und dem Nullpunkt-Korrekturwert erhalten wird.

11. Vorrichtung nach Anspruch 5, 6, 7, 8, 9 oder 10 zur Anwendung in einem kombinatorischen Wägesystem mit mehreren solcher Wägemaschinen (101-1 bis 101-n, 102-1 bis 102-n) und betreibbar zur Durchführung der Nullpunktjustierung jeder dieser Wägemaschinen.

Revendications

1. Procédé de réglage automatique de point zéro d'une machine de pesage, comprenant les étapes suivantes:

(a) fourniture d'une valeur (Wz, Wz', Wc, Wzi) de correction de point zéro, d'une grandeur initiale présélect nnée;

(b) calcul d'une valeur (Ws, Wd, Wdi) de différence entre la valeur (Wz, Wz', Wc, Wzi) de

correction de point zéro et une valeur (Wi) de poids déchargé, produite par la machine de pesage quand la machine st sans charge;

(c) comparais n de la valeur (Ws, Wd, Wdi) de différence avec un valeur (Wr) de référence préétablie d'une grandeur prédéterminée;

(d) changement de la valeur (Wz, Wz', Wc, Wzi) de correction de point zéro conformément aux grandeurs relatives des valeurs comparées; et après cela

répétition des étapes (b) à (d), pour rendre la valeur (Ws, Wd, Wdi) de différence essentiellement égale à la valeur (Wr) de référence préétablie.

2. Procédé selon la revendication 1, la grandeur présélectionnée de la valeur (Wz, Wz', Wc, Wzi) de correction de point zéro étant à mi-chemin entre des grandeurs minimale et maximale possibles de la valeur de correction de point zéro, dans lequel, au cours de la première exécution des étapes (b) à (d), et une première condition se présente, dans laquelle la valeur (Ws, Wd, Wdi) de référence est supérieure en grandeur à la valeur (Wr) de référence préétablie, la valeur de correction de point zéro est augmentée en grandeur, et si une seconde condition se présente, dans laquelle la valeur (Ws, Wd, Wdi) de différence est inférieure ou égale en grandeur à la valeur (Wr) de référence préétablie, la valeur de correction de point zéro est réduite en grandeur, l'importance de l'augmentation ou de diminution étant égale à la moitié de ladite grandeur présélectionnée, et dans lequel au cours du chaque exécution suivante des étapes (b) à (d), la valeur de correction de point zéro est soumise à une augmentation ou à une diminution en grandeur, selon que c'est la première ou la seconde condition qui se présente, de la moitié de l'importance de l'augmentation ou de la diminution effectuée au cours de l'exécution précédente des étapes (b) à (d).

3. Procédé selon la revendication 2, dans lequel la valeur (Wz, Wz', Wc, Wzi) de correction de point zéro est fournie comme valeur numérique (Wz, Wz', Wzi) sous la forme d'un nombre binaire de m bits, la valeur de correction de point zéro étant portée à la grandeur initiale présélectionnée de l'étape (a) en mettant le m^{ième} bit de nombre binaire à "1" et les bits restants à "0",

et dans lequel, au cours de la première exécution des étapes (b) à (d), et la première condition se présente, le (m−1)^{ième} bit du nombre binaire est mis à "1", avec le m^{ième} bit inchangé, tandis que, si la seconde condition se présente, le m^{ième} bit est mis à "0" et le (m−1)^{ième} bit est mis à "1", pais au cours de la n^{ième} exécution des étapes (b) à (d), où n est un nombre entier supérieur à 1, si la première condition se présente, la (m−n)^{ième} bit du nombre binaire est mis à "1", avec le m^{ième} jusqu'au (m−n+1)^{ième} bits inchangés, et si la seconde condition se présente, le (m−n+1)^{ième} bit est mis à "0" et le (m−n)^{ième} bit st mis à "1".

4. Procédé selon la revendication 3, dans lequel le calcul de l'étap (b) est effectué sur la base d'un valeur analogique (Wi) de poids et d'une version analogique (Wc) de la valeur de correction de point zéro obtenue par conversion numérique-anal gique de nombre binair à n bits, et la c mparaison de l'étape (c) est effectuée sur la base du résultat analogique (Ws) de ce calcul et d'une valeur de référence (Wr) analogique préétablie.

5. Appareil de réglage de zéro à utiliser avec une machine de pesage que l'on peut faire fonctionner pour fournir une sortie donnant une valeur de poids qui est fonction du poids de la charge appliquée à la machine de pasage, l'appareil comprenant:

un soustracteur (104) pouvant fonctionner pour calculer une valeaur (Ws, Wd, Wdi) de différence entre une valeur (Wz, Wz', Wc, Wzi) de correction de point zéro, initialement d'une grandeur présélectionnée, fournie par l'appareil et une valeur (Wi) de poids déchargé produits par la machine de pasage (de 101-1 à 101-n, de 102-1 à 102-n) quand la machine est sans charge;

un comparateur (106) que l'on peut faire fonctionner pour comparer la valeur (Ws, Wd, Wdi) de différence avec une valeur (Wr) de référence préétablie d'une grandeur prédéterminée et pour fournir une sortie (CRS) dont la valeur est fonction des grandeurs relatives des valeurs comparées;

une unité (107) du commande, que l'on peut faire fonctionner pour changer la valeur (Ws, Wz', Wc, Wzi) de correction de point zéro conformément à la valeur de la sortie (CRS) du comparateur, laquelle valeur modifiée de correction de point zéro est fournie au soustracteur (104) pour une autre opération du soustracteur (104), au comparateur (106) et à l'unité de commande (107), pour rendre la valeur (Ws, Wd, Wdi) de différence essentiellement égale à la valeur (Wr) de référence préétablie.

6. Appareil selon la revendication 5, la grandeur initiale présélectionnée de la valeur (Wz, Wz', Wc, Wzi) de correction de point zéro étant fixée à mi-chemin entre des grandeurs minimale et maximale possibles de la valeur de correction de point zéro, dans lequel, au cours d'une première opération de soustracteur (104), du comparateur (106) et de l'unité de commande (107), avec la valeur de correction de point zéro établie à la grandeur présélectionnée initiale, si une première condition se présente, dans laquelle la valaur (Ws, Wd, Wdi) de différence est supérieure en grandeur à la valeur (Wt) de référence préétablie, la valeur de correction de point zéro est augmentée en grandeur, et si une seconde condition se présente, dans laquelle la valeur (Ws, Wd, Wdi) de différence est inférieure ou égale en grandeur à la valeur (Wr) de référence préétablie, la valeur de correction de point zéro est diminuée en grandeur, l'importance de l'augmentation ou du la diminution étant égale à la moitié de ladite grandeur présélectionnée, et dans lequel, au cours de chaque opération suivante du soustracteur (104), du c mparateur (106) t de l'unité (107) de commande, la valeur de c rrecti n d point zéro est s umis à une augmentati n ou à une diminution en grand ur, selon qu c' st la première ou la seconde conditi n qui se présente, de la moitié de

l'importance de l'augmentation ou de la diminution effectuée au cours de l'opérati n qui précèd .

7. Appareil selon la revendication 6, dans lequel la valeur (Wz, Wz', Wc, Wzi) de correction du point zéro est fournie en tant que valeur numérique (Wz, Wz', Wzi) sous la forme d'un nombre binaire de m bits, la valeur de correction de point zéro étant portée à la grandeur initiale présélectionnée en mettant le $m^{ième}$ bit du nombre binaire à "1" et les bits restants à "0",

et dans lequel, au cours de la première opération du soustracteur (104), du comparateur (106) et de l'unité de commande (107), si la première condition se présente, le $(m-1)^{ième}$ bit du nombre binaire est mis à "1", avec le $m^{ième}$ bit inchangé, tandis que si la seconde condition ses présente, le $m^{ième}$ bit est mis à "0" et le $(m-1)^{ième}$ bit est mis à "1", puis au cours de la $n^{ième}$ opération du soustracteur 104, du comparateur (106) et de l'unité de commande (107), où n est un nombre entier plus grand que 1, si la première condition se présente, le $(m-n)^{ième}$ bit du nombre binaire est mis à "1", avec le $m^{ième}$ au $(m-n+1)^{ième}$ bits inchangés, et si la seconde condition se présente, le $(m-n+1)^{ième}$ bit est mis à "0" et le $(m-n)^{ième}$ bit est mis à "1".

8. Appareil selon la revendication 5, 6 ou 7, dans lequel le soustracteur (104) est agencé pour recevoir une valeur analogique (Wi) de poids et une version analogique (Wc) de la valeur de correction de point zéro obtenue par une conversion numérique-analogique du nombre binaire de m bits, t le comparateur (106) est agencé pour recev ir le résultat analogiqu (Ws) du calcul du soustracteur (104) et une valeur analogique (Wr) de référence préétablie.

9. Appareil selon la revendication 8, comprenant un convertisseur numérique-analogique (108) et un diviseur de tension (109) pouvant fonctionner de façon à déduire la version analogique (Wc) de la valeur de correction de point zéro à partir du nombre binaire de m bits.

10. Appareil selon la revendication 5, 6, 7, 8 ou 9, dans lequel l'unité (107) de commande pour fonctionner pour stocker une représentation numérique (Wz, Wzi) de la valeur de correction de point zéro, finalement obtenue, quand la valeur (Ws, Wd, Wdi) de différence à été rendue essentiellement égale à la valeur (Wr) de référence actuelle, et pour stocker une représentation numérique (Wd, Wdi) de cette valeur de différence, grâce à quoi lorsqu'une valeur de poids est extraite de la machine de pesage, une valeur vrale de poids est obtenue en soustrayant la valeur de différence stockée de la différence entre la valeur de poids extraite et la valeur de correction de point zéro.

11. Appareil selon la revendication 5, 6, 7, 8, 9 ou 10, à utiliser avec un système de pesage combinatoire comprenant une pluralité de telles machines de pesage (de 101-1 à 101-n, de 102-1 à 102-n), pouvant fonctionner pour exécuter le réglage de point zéro pour la totalité des machines de pesage.

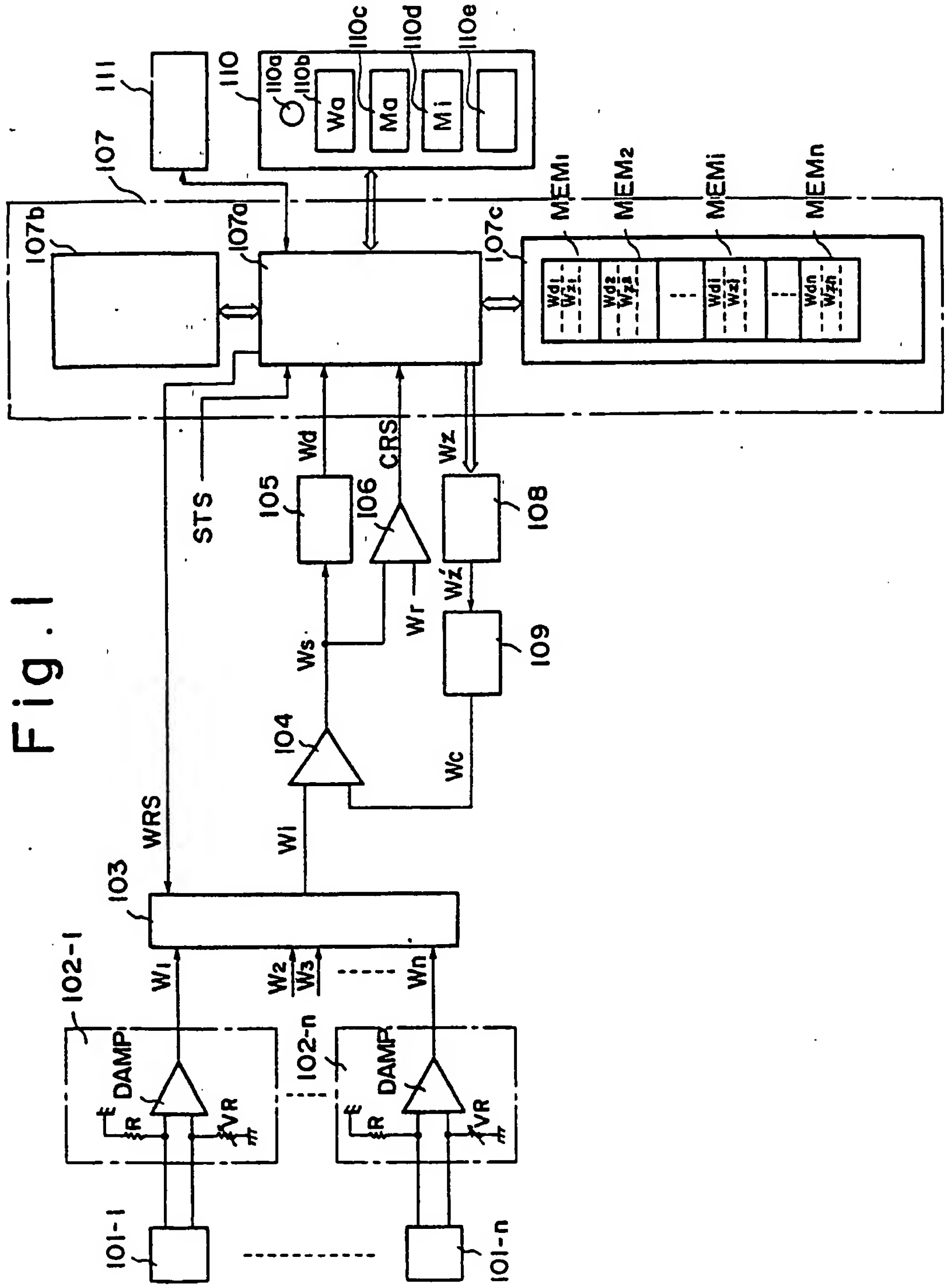

101-1
101-n
102-1
102-n
DAMP
R
VR
W1
W2
W3
Wn
103
WRS
Wi
104
Ws
Wr
105
106
Wd
CRS
STS
108
Wz
Wz'
109
Wc
107
107a
107b
107c
MEM1
MEM2
MEMi
MEMn
Wd1
Wz1
Wd2
Wz2
Wdi
Wzi
Wdn
Wzn
110
110a
110b
110c
110d
110e
Wa
Ma
Mi
111

Fig. 1

Fig. 2

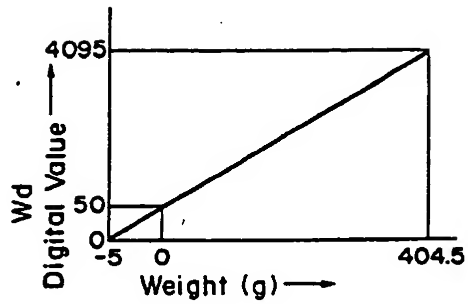

4095
50
0
Wd
Digital Value
-5
0
404.5
Weight (g)

Fig. 3

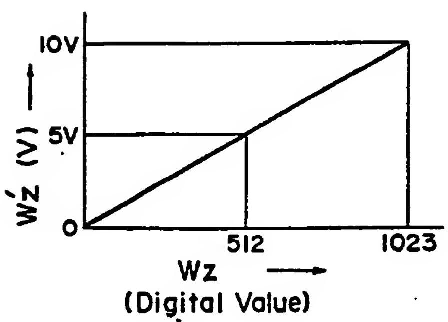

10V
5V
0
W'z (V)
512
1023
Wz
(Digital Value)

Fig. 4

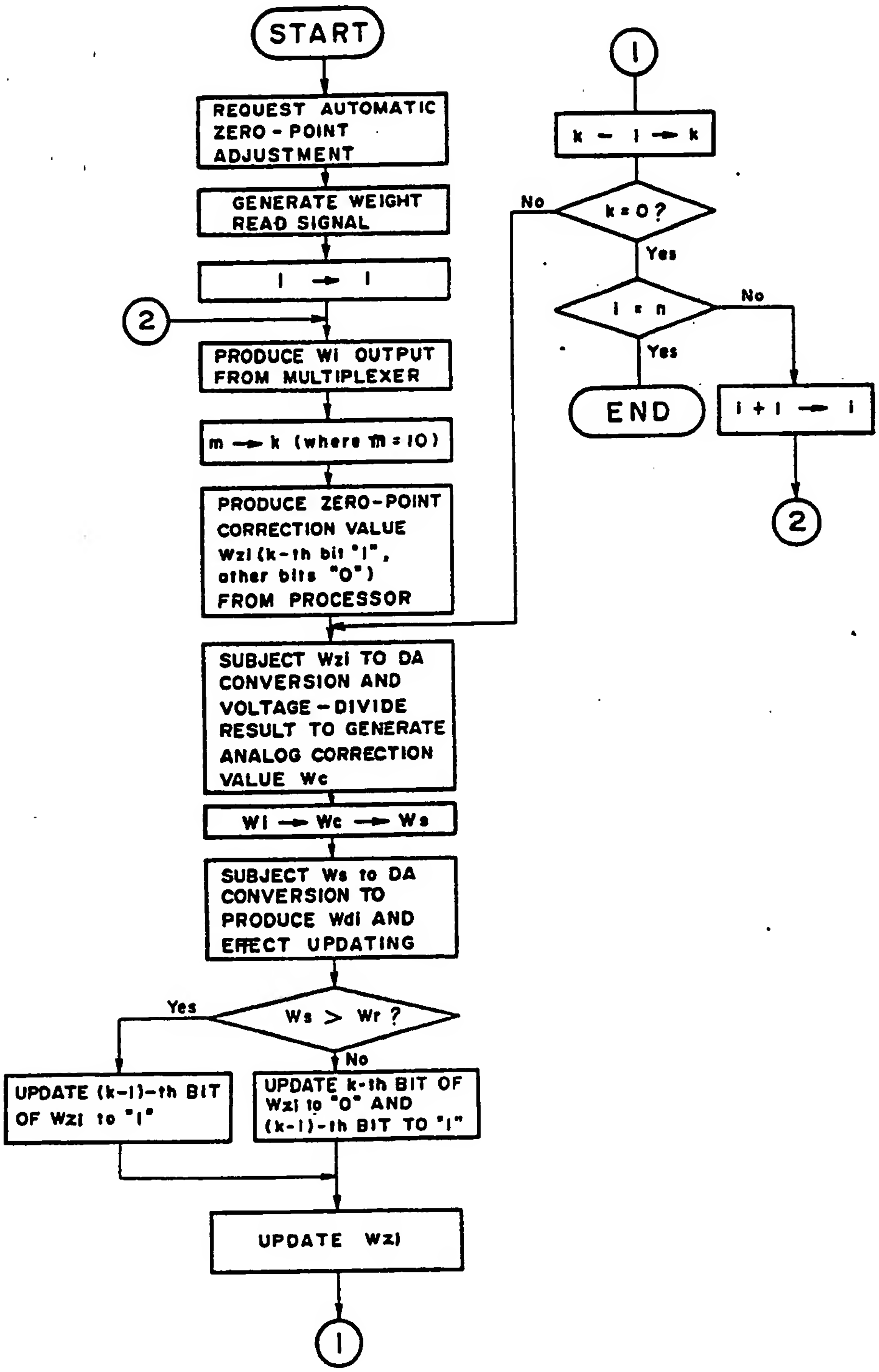
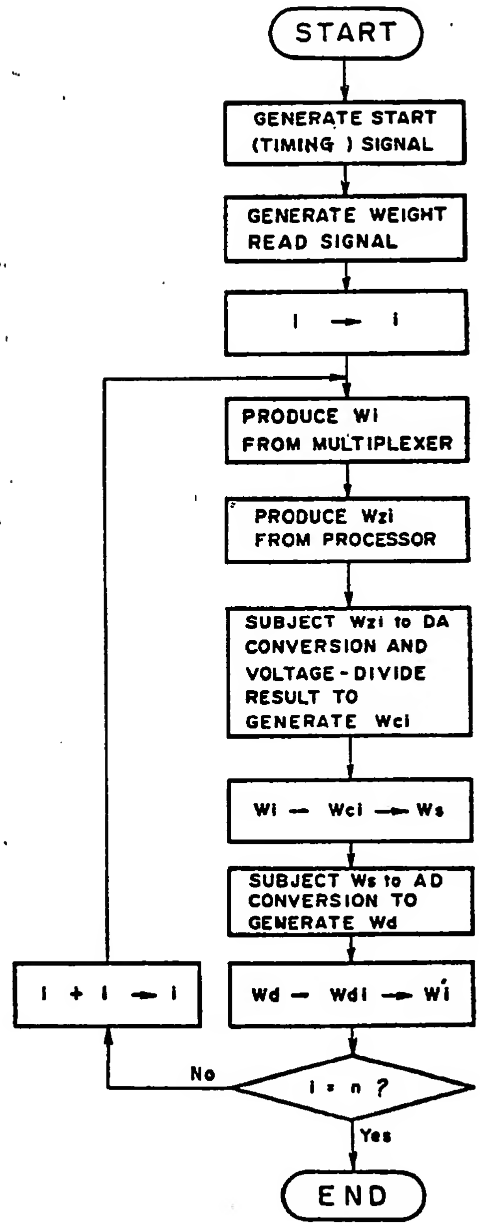

START
REQUEST AUTOMATIC ZERO-POINT ADJUSTMENT
GENERATE WEIGHT READ SIGNAL
1 → i
2
PRODUCE Wi OUTPUT FROM MULTIPLEXER
m → k (where m = 10)
PRODUCE ZERO-POINT CORRECTION VALUE Wzi (k-th bit "1", other bits "0") FROM PROCESSOR
SUBJECT Wzi TO DA CONVERSION AND VOLTAGE-DIVIDE RESULT TO GENERATE ANALOG CORRECTION VALUE Wc
Wi → Wc → Ws
SUBJECT Ws to DA CONVERSION TO PRODUCE Wdi AND EFFECT UPDATING
Ws > Wr ?
Yes
No
UPDATE (k-1)-th BIT OF Wzi to "1"
UPDATE k-th BIT OF Wzi to "0" AND (k-1)-th BIT TO "1"
UPDATE Wzi
1
1
k − 1 → k
k = 0 ?
No
Yes
i = n
No
Yes
END
i + 1 → i
2

Fig. 5


START
GENERATE START (TIMING) SIGNAL
GENERATE WEIGHT READ SIGNAL
1 → i
PRODUCE Wi FROM MULTIPLEXER
PRODUCE Wzi FROM PROCESSOR
SUBJECT Wzi to DA CONVERSION AND VOLTAGE - DIVIDE RESULT TO GENERATE Wci
Wi − Wci → Ws
SUBJECT Ws to AD CONVERSION TO GENERATE Wd
Wd − Wdi → Wi'
i = n ?
No
i + 1 → i
Yes
END